Reminder: *We need to develop a response to the following summary of the public comments received on landslides. We need to make sure we strengthen our rationale to address any apparent weaknesses the public pointed out in our proposed findings.*

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Others expressed their disagreement with the federal agencies' recent decision and argued that the evidence provided by the federal entities was misleading, only focusing on "landslide density relationships" rather than considering the "total number of landslides triggered during major storms". If consider the latter, one would see that the "potential increases in sediment delivery to public resources from landslides...is proportionally small". In addition, it was argued that EPA has not offered objective evidence that additional management measures are needed to maintain water quality. It was recommended that EPA consider a broader scale view over longer timeframes to evaluate whether water quality and designated uses are impaired. The commenter added that the federal agencies have not produced any evidence that landslides resulting from forest management activities have caused exceedances in water quality or negatively impacted aquatic life.

Landslide Prone Areas

Oregon proposes to address this element of the additional management measures for forestry condition through a mix of regulatory and voluntary approaches. While the state has adopted more protective forestry rules to reduce landslide risks to life and property and promotes some voluntary practices to reduce landslide risks through the Oregon Plan for Salmon and Watersheds (The Oregon Plan), Oregon still does not have additional management measures for forestry in place to protect high risk landslide areas to ensure that water quality standards and designated uses are achieved.
Since receiving conditional approval on January 13, 1998, Oregon amended the Oregon FPA rules to require the identification of landslide hazard areas in timber harvesting plans and road construction and place certain restrictions on harvest and road activities within these designated high-risk landslide areas for public safety(OAR 629-623-0000 through 629-623-0800). However, under these amendments, shallow, rapidly moving landslide hazards directly related to forest practices are addressed only as they relate to risks for losses of life and property, not for potential water quality impacts. Oregon still allows timber harvest and the construction of forest roads, where alternatives are not available, on high-risk landslide hazard areas as long as it is not deemed a public safety risk.

In addition to these regulatory programs, Oregon employs a voluntary measure under the Oregon Plan that gives landowners credit for leaving standing live trees along landslide prone areas as a source of large wood. The large wood, which may eventually be deposited into stream channels, contributes to stream complexity, a key limiting factor for coastal coho salmon recovery. While this is a good management practice, the measure is not designed to protect high-risk erosion areas but rather to ensure large wood exists to provide additional stream complexity when a landslide occurs.

As noted in the January 13, 1998, findings, timber harvests on unstable, steep terrain can result in increases in landslide rates which contribute to water quality impairments. A number of studies continue to show significant increases in landslide rates after clear-cutting compared to unmanaged forests in the Pacific Northwest. For example, Robinson et. al (1999) found that three out of four areas studied in very steep terrain and landslide densities and erosion volumes greater in stands that were clearcut during the previous nine years. [1] Research by XX, Montgomery et. al (2000), and Turner et. al. (2010) is also consistent with this finding that timber harvest increase landslide rates. XX found that timber harvests on unstable, steep terrain can result in increases in landslide rates of approximately 200 to 400 percent.[2] (I need to include a footnote for this document) Montgomery et. al. (2000)[3] concluded that landslide rates in Mettman Ridge in the Oregon Coast Range increased after clear cutting at a rate of three to nine times the background rate for the region. The regional analysis from the Mettman Ridge study found that forest clearing dramatically accelerates shallow landsliding in steep terrain typical of the Pacific Northwest.

Turner et al. (2010)[4], also found that rain fall intensity, slope steepness, and stand age contributed to landslide rates. Very few landslides occurred when rainfall was less than or equal to a 100-year rainfall event) and at higher rainfall intensities, steep slopes had significantly higher landslide densities compared to lower gradient slopes. In addition, they found that at higher rainfall intensities, the density of landslides in recently harvested sites was roughly two to three times the landslide density in older stands.

Schmidt et. al (2001) examined the role of root cohesion on landslide susceptibility in forested landscapes. Root cohesion is a measure of the lateral reinforcing strength the root system provides.[5] A higher root cohesion, the better the root system can stabilize the soil, reducing the risk of landslides.. Schmidt et. al. found that median lateral root cohesion is less for industrial forests with significant understory and deciduous vegetation (6.8–23.2 kPa) compared to natural forests dominated by conifers (25.6–94.3 kPa). In clearcuts, Schmidt et. al found that lateral root cohesion is uniformly less than or equal to 10 kPa, making these areas much more susceptible to landslide.

In 2004, Sakals and Sidle modeled the effect of different harvest methodologies on root cohesion over time. [9] They found that, of the methodologies examined (clear-cutting, single-tree selection cutting, and strip-cutting), clear-cutting produces the greatest decline in root cohesion.

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[1] Robison, G.R., Mills, K.A., Paul, J. Dent, L. and A. Skaugset. 1999. Oregon Department of Forestry Storm Impacts and Landslides of 1996: Final Report. Oregon Department of Forestry Forest Practices Monitoring Program. Forest Practices Technical Report Number 4.157 pages.

[2] [citation or other study]

[3] Montgomery, D. R., K. M. Schmidt, H. M. Greenberg & W. E. Dietrich, 2000. Forest clearing and regional landsliding. Geology 28: 311–314.

[4] Turner, T.R., Duke, S.D., Fransen, B.R., Reiter, M.L., Kroll, A.J., Ward, J.W., Bach, J.L., Justice, T. E., and R.E. Bilby. 2010. Landslide densities associated with rainfall, stand age, and topography on forested landscapes, southwestern Washington, USA. Forest Ecology and Management 259 (2010) 2233–2247

[5] Wu, T.H. 1995. Slope stabilization. *In* Slope stabilization and erosion control: A bioengineering approach. *Edited by* R.P.C. Morgan and R.J. Rickson. E & FN Spon, London, pp. 221–264.

[9] Sakals, M.E. and R.C. Sidle. 2004. A spatial and temporal model of root cohesion in forest soils. Canadian Journal of Forest Research 34(4): 950-958.

Further, that root cohesion may continue to decline for 30 years post-harvest. That decline is attributed to the decay of the root systems of the harvested trees, and the fact that young root systems have smaller root volumes and less radial rooting extent. They concluded that clear-cutting on hazard slopes could increase the number of landslides as well as the probability of larger landslides. They also stated that a management approach requiring the retention of conifers on high-risk slopes would increase root cohesion and reduce the risk of landslide.

Not only has the science demonstrated that timber harvesting can contribute to landslides but that these landslides also degrade water quality and impair designated uses. In 2013, the Cooperative Monitoring Evaluation and Research committee (CMER) of the Washington State Department of Natural Resources published a study that explored landslide response to a large 2007 storm in Southwestern Washington[10]. Within the 91 square mile study area, a total of 1147 landslides were found within harvest units that delivered to public resources (mostly streams). The majority (82%) occurred on hillslopes and the rest initiated from roads. In examining these landslides, the study found that unstable hillslopes with no buffer had a significantly (65%) higher landslide density than did mature stands. Unstable slopes with no buffer also delivered 347% more sediment than slopes with mature stands. The authors conclude that buffers on unstable slopes likely reduce landslide density and sediment volume. This has important implications for water quality and beneficial uses. It is well documented that sediment can clog and damage fish gills, suffocate fish eggs, smother aquatic insect larvae, and fill in spaces in streambed gravel where fish lay eggs. Sediment can also carry other pollutants into waterbodies, creating issues for domestic water supply and public water providers.

Therefore, there is abundant evidence additional management measures to provide greater protection of landslide prone areas for the protection of water quality in Oregon is warranted. To meet this additional management measure requirement, the state must adopt similar harvest and road construction restrictions for all high-risk landslide prone areas with the potential to impact water quality and designated uses, not just those areas where landslides pose risks to life and property. These restrictions could be site specific taking into account factors such as slope, geology and geography on existing or planned land management activities. The state may also want to consider using slope instability screening tools that help identify high-risk landslide areas to minimize landslide rates and potential impacts to water quality and beneficial uses.

If the Oregon plans to rely on voluntary efforts, the state must describe the full suite of voluntary practices it plans to use address this management measure, how the state will promote these voluntary practices, and meet the other requirements when using voluntary programs to meet 6217(g) management measure requirements (i.e., a legal opinion asserting the state has back-up authority to ensure implementation of the management measure, a commitment to use the back-up authority, and a description of the monitoring and tracking program the state will use to assess how it will monitor and track implementation of the voluntary approach.

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[10] Stewart, G., Dieu, J., Phillips, J., O'Connor, M., Veldhuisen C., 2013, The Mass Wasting Effectiveness Monitoring Project: An examination of the landslide response to the December 2007 storm in Southwestern Washington; Cooperative Monitoring, Evaluation and Research Report CMER 08- 802; Washington Department of Natural Resources, Olympia, WA.

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Landslide Prone Areas

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Comment [AC1]: Stick with this original language as it was written this way on purpose—to match the language we used in the 1998 conditional approval findings.

Since receiving conditional approval on January 13, 1998, Oregon amended the Oregon FPA rules to require the identification of landslide hazard areas in timber harvesting plans and road construction and place certain restrictions on harvest and road activities within these designated high-risk landslide areas for public safety (OAR 629-623-0000 through 629-623-0800). However, under these amendments, shallow, rapidly moving landslide hazards directly related to forest practices are addressed only as they relate to risks for losses of life and property, not for potential water quality impacts. Oregon still allows timber harvest and the construction of forest roads, where alternatives are not available, on high-risk landslide hazard areas as long as it is not deemed a public safety risk.

In addition to these regulatory programs, Oregon employs a voluntary measure under the Oregon Plan that gives landowners credit for leaving standing live trees along landslide prone areas as a source of large wood. The large wood, which may eventually be deposited into stream channels, contributes to stream complexity, a key limiting factor for coastal coho salmon recovery. While this is a good management practice, the measure is not designed to protect

high-risk erosion areas but rather to ensure large wood exists to provide additional stream complexity when a landslide occurs.

As noted in the January 13, 1998, findings, timber harvests on unstable, steep terrain can result in increases in landslide rates which contribute to water quality impairments. A number of studies continue to show significant increases in landslide rates after clear-cutting compared to unmanaged forests in the Pacific Northwest. ~~In a study completed in June 1999, "Oregon Department of Forestry, Storm Impacts and Landslides of 1996: Final Report"~~ For example, Robinson et. al (1999) ~~indicated~~ found that ~~in~~ three out of four areas studied in very steep terrain and~~, both~~ landslide densities and erosion volumes ~~were~~ greater in stands that ~~which~~ were clearcut during~~in~~ the previous nine years.[1] ~~–~~Research by XX, Montgomery et. al (2000), and Turner et. al. (2010) is also consistent with this finding that timber harvest increase landslide rates. ~~Other evidence~~ XX found that ~~indicates that~~ timber harvests on unstable, steep terrain can result in increases in landslide rates of approximately 200 to 400 percent.[2] ~~-~~ (I need to include a footnote for this document)

~~For example, in the 2000 study, "Forest Clearing and Regional Landsliding,"~~ Montgomery et. al. (2000)[3], concluded that landslide rates in Mettman Ridge in the Oregon Coast Range increased after clear cutting at a rate of three to nine times the background rate for the region. ~~-~~The regional analysis from ~~this~~ the Mettman Ridge study found that forest clearing dramatically accelerates shallow landsliding in steep terrain typical of the Pacific Northwest.

~~Another study by~~ Turner et al. (2010)[4], ~~which Oregon also cited in its July 2013 submission, indicated~~ also found that rain fall intensity, slope steepness, and stand age contributed to landslide rates. Very few landslides occurred when rainfall was less than or equal to a 100-year rainfall event) and at ~~that at~~ higher rainfall intensities, steep slopes had significantly higher landslide densities ~~occurred on steep slopes~~ compared to lower gradient slopes. In addition, they ~~The study also~~ found that at higher rainfall intensities, the density of landslides in recently harvested sites was roughly two to three~~2-3~~ times the landslide density in older stands.

Schmidt et. al (2001) examined the role of root cohesion on landslide susceptibility in forested landscapes. Root cohesion is a measure of the lateral reinforcing strength the root system provides.[5] A higher root cohesion, the better the root system can stabilize the soil, reducing the risk of landslides. ~~One reason landslides on hazard slopes are closely associated with forest~~

Comment [CJ2]: You described two studies: 2010 & 2000. Where can the others be found? Also would be helpful to explicitly link the 2010 & 2000 study results to the deficiencies in Oregon's program (i.e. 2000 study indicates Oregon should consider developing MMs to prevent clear cutting in landslide hazard areas or 2010 study indicates Oregon should consider developing MMs needed to prevent harvesting of younger trees in steep slopes with certain amount of rainfall …).

Comment [AC3]: Need to provide citation for this study.

Comment [KT4R3]: I know this statement was made in our 1998 findings, but the 1998 document does not include a citation. Alan – do you know where this came from?

Ex. 5 - Deliberative

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[1] Robison, G.R., Mills, K.A., Paul, J. Dent, L. and A. Skaugset. 1999. Oregon Department of Forestry Storm Impacts and Landslides of 1996: Final Report. Oregon Department of Forestry Forest Practices Monitoring Program. Forest Practices Technical Report Number 4.157 pages. ~~[citation for Robinson et. al 1999 study.~~

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~~clearing is root cohesion. R~~[6]. [7]Schmidt et. al. found that median lateral root cohesion ~~(measured in kilopascals, a measurement of pressure)~~ is less for industrial forests with significant understory and deciduous vegetation (6.8–23.2 kPa) compared to natural forests dominated by conifers (25.6–94.3 kPa). In clearcuts, ~~the~~Schmidt et. al ~~paper~~found that lateral root cohesion is uniformly less than or equal to 10 kPa, making these areas much more susceptible to landslide.

~~In a 2004 paper,~~ In 2004, Sakals and Sidle[8] modeled the effect of different harvest methodologies on root cohesion over time.[9] ~~-~~They found ~~ir findings suggest~~ that, of the methodologies examined (clear-cutting, single-tree selection cutting, and strip-cutting), clear-cutting produces the greatest decline in root cohesion. Further, that root cohesion may continue to decline for 30 years post-harvest. That decline is attributed to the decay of the root systems of the harvested trees, and the fact that young root systems have smaller root volumes and less radial rooting extent. ~~Their findings~~ They concluded that ~~imply that~~ clear-cutting on hazard slopes could increase the number~~s~~ of landslides as well as the probability of larger landslides. They also stated that ~~A~~a management approach requiring the retention of conifer~~sous vegetation~~ on high-~~-~~risk slopes would increase root cohesion and reduce the risk of landslide.

~~-~~Not only has the science demonstrated that timber harvesting can contribute to landslides but that these landslides also degrade water quality and impair designated uses ~~in coastal Oregon~~. In 2013, the Cooperative Monitoring Evaluation and Research committee (CMER) of the Washington State Department of Natural Resources published a study that explored landslide response to a large 2007 storm in Southwestern Washington[10]. Within the 91 square mile study area, a total of 1147 landslides were found within harvest units that delivered to public resources (mostly streams). The majority (82%) occurred on hillslopes and the rest initiated from roads. In examining these landslides, the study found that unstable hillslopes with no buffer had a significantly (65%) higher landslide density than did mature stands. Unstable slopes with no buffer also delivered 347% more sediment than slopes with mature stands. The authors conclude that buffers on unstable slopes likely reduce landslide density and sediment volume. This has important implications for water quality and beneficial uses. It is well documented that sediment can clog and damage fish gills, suffocate fish eggs, smother aquatic insect larvae, and fill in spaces in streambed gravel where fish lay eggs. Sediment can also carry other pollutants into waterbodies, creating issues for domestic water supply and public water providers.

~~For example,...[include a study or two or evidence from 303(d) listing? that shows timber harvest driven landslides are bad for water quality].~~

Ex. 5 - Deliberative

Comment [AC7]: What other methodologies were examined? Would adopted one of the other methodologies be a bmp we'd want to promote?

Comment [KT8R7]: They found that single tree selection decreased root cohesion the least (19% decrease). Not sure if we want to promote single tree selection as a bmp – but good information to have in our pocket.

Comment [AC9]: I'm assuming this is what they said in their discussion and not an inference we are making?

Comment [AC10]: Is this something they recommended or something we are concluding from their statement. Assuming it's the researches in which case we should be clear.

Comment [KT11R10]: I'm fine with these edits

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[6] ~~Wu, T.H. 1995. Slope stabilization. *In* Slope stabilization and erosion control: A bioengineering approach. *Edited by* R.P.C. Morgan and R.J. Rickson. E & FN Spon, London, pp. 221–264.~~

[7] ~~Schmidt, K.M., Roering, J.J., Stock, J.D., Dietrich, W.E., Montgomery, D.R., and Schaub, T. 2001. Root cohesion variability and shallow landslide susceptibility in the Oregon Coast Range. Canadian Geotechnical Journal, 38: 995–1024.~~

[8] ~~Sakals, M.E. and R.C. Sidle. 2004. A spatial and temporal model of root cohesion in forest soils. Canadian Journal of Forest Research 34(4): 950-958.~~

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Therefore, there is abundant evidence additional management measures to provide greater protection of landslide prone areas for the protection of water quality in Oregon is warranted. To meet this ~~e~~ additional management measure ~~relating to high-risk landslide prone areas requirement, ,~~ the s~~S~~tate must adopt similar harvest and road construction restrictions for all high-risk landslide prone areas with the potential to impact water quality and designated uses, not just those areas where landslides pose risks to life and property. ~~-~~ These restrictions could be site specific taking into account factors such as slope, geology and geography o~~r~~n existing or planned land management activities. ~~-~~The state may also want to consider using slope instability screening tools that help identify high-risk landslide areas to minimize landslide rates and potential impacts to water quality and beneficial uses.

Comment [AC12]: But what are the bmps that they should use once the high-risk areas are identified?

~~The State employs a voluntary measure under the Oregon Plan that gives landowners credit for leaving standing live trees along landslide prone areas as a source of large wood. The large wood, which may eventually be deposited into stream channels, contributes to stream complexity, a key limiting factor for coastal coho salmon recovery.~~

If the Oregon plans to rely on voluntary efforts, the state must describe the full suite of voluntary practices it plans to use address this management measure, how the state will promote these voluntary practices, and meet the other requirements when using voluntary programs to meet 6217(g) management measure requirements (i.e., a legal opinion asserting the state has back-up authority to ensure implementation of the management measure, a commitment to use the back-up authority, and a description of the monitoring and tracking program the state will use to assess how it will monitor and track implementation of the voluntary approach. ~~While Oregon desires to better capture and evaluate the implementation and effectiveness of voluntary measures, the state has not shown how it intends to do to demonstrate how these voluntary programs ensure water quality and designated uses are protected from landslide impacts, nor has Oregon provided a commitment to exercise those back-up authorities where necessary to protect water quality and designated uses to ensure implementation of this measure. These are required elements if a state chooses to use voluntary programs to support its coastal nonpoint program (see the federal agencies' 1998 Final Administrative Changes guidance).~~